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AUTHOR Hedges, Larry V.
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ABSTRACT

This study investigated the long term effects of the Personalized System of Instruction (PSI) method at the University of California, San Diego. Groups of 139 and 137 undergraduate students took three physics courses taught by either the PSI method or the lecture/discussion method. Students from these groups were compared in two subsequent chemistry courses and a subsequent biology course. The chemistry and biology courses were taught using lectures and discussion sections. The PSI group achieved significantly higher grades in both the physics courses and the subsequent courses. The fact that the PSI students achieved higher grades in the subsequent lecture courses seems to indicate that they were not at a disadvantaged because of the earlier PSI courses. The junior year major area grades of students who majored in applied mathematics and engineering sciences, biology, chemistry, and physics were also compared. In each case, the PSI group achieved significantly higher grades. For each comparison, the mean high school grade point average, SAT scores, and freshman university grade point average were used to verify that no selected attrition had occurred.
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Personalized Introductory Courses:

A Longitudinal Study

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Larry V. Hedges

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EDUCATION

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Office of Academic Support and Instructional Services
Kenneth Majer, Director

Office of Student Affairs
George S. Murphy, Vice Chancellor

Office of Academic Affairs
Paul D. Saltman, Vice Chancellor

University of California, San Diego
La Jolla, California 92093

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Abstract

Groups of 139 and 137 undergraduate students took three physics courses taught by either the personalized system of instruction or the lecture/discussion method. Students from these groups were compared in two subsequent chemistry courses and a subsequent biology course. The PSI group achieved significantly higher grades in each case. The junior year major area grades of students who majored in Applied Mechanics and Engineering Sciences, Biology, Chemistry and Physics were also compared. In each case, the PSI group achieved significantly higher grades. For each comparison, the mean high school grade point average, SAT scores and freshman university grade point average were used to verify that no selective attrition had occurred.

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In 1965, Fred Keller and J. Gilmour Sherman introduced a radically new method of teaching undergraduate psychology at Arizona State University (Sherman, 1974). Since that time, increasing numbers of college educators have begun to use this new teaching method known as the Personalized System of Instruction (PSI). Although PSI is probably still more popular in psychology than any other discipline, it is now widely used in science curricula.

PSI differs from the traditional lecture-discussion-exam method in five ways. First, course material is broken down into a number of units, each with its own specific learning objectives. Second, mastery of those objectives is required of each student before that student can go on to the next unit, although this may take several attempts. Third, students progress through the units at their own pace. Fourth, written materials rather than lectures are used to present the vital information in the course. Finally, there is an emphasis on the proctor-student interaction during the test grading/tutoring sessions of the course. The proctors are usually undergraduates who have completed the course and are motivated to tutor by some combination of money, credit or recognition (Keller, 1968).

Because PSI departs significantly from traditional instruction, many users of PSI have conducted research on the new method. Usually this research compares students from a PSI class with students from traditional classes covering the

same mat ial. The instrument used for comparison of content acqui.ition has usually been a final exam prepared jointly by the instructors of the traditional and PSI classes respectively. In one of the first such comparisons, Austin and Gilbert (1973) selected 25 students at random from a conventional course in electromagnetism and taught them in a Keller Plan format. These students performed substantially better on the final examination than the rest of the students who were taught conventionally. Morris and Kimbrell (1972), Born, et al. (1972), and Coorey and McMichael (1974) all compared two different class sections covering the same material in introductory psychology classes. In each case, the PSI section performed better than the conventional section on a common final exam. Kulik (1975) in a recent review of the literature found that 30 of 31 comparisons of final exam performance between PSI and lecture groups favored the PSI group. Hence, it seems that superior end-of-course performance of PSI students is fairly well established.

These results, along with the nearly unanimous preference of PSI over conventional instruction by students has encouraged the upsurge of interest in PSI (Kulik, 1975). The most tangible manifestation of this interest is the growing number of PSI courses, mostly at the introductory level in science curricula.

Problem

The large scale use of PSI at the introductory level raises its own set of questions. While final exam comparisons

address the question of content acquisition, introductory courses usually have the additional purpose of preparing students for further work in the same or related disciplines. Therefore, it is plausible that PSI students would find themselves at a disadvantage in later conventional courses when compared to students from conventional courses. If this were the case, the desirability of PSI as an instructional method would be severely questioned, especially in relation to introductory courses.

Three studies have examined the performance of PSI students and lecture students in the course following PSI instruction. Anderson and Artman (1972) compared students from PSI and lecture courses in physics during the (conventionally taught) subsequent physics course. The former PSI students received significantly higher grades than the former lecture students. Lubkin (1974) and Weissberg (1973) obtained similar results in their studies of PSI engineering students in a subsequent conventional course. These studies seem to indicate that PSI students perform well in a conventional course following the PSI course. One limitation, however, is that neither study addresses the question of PSI students' performance in later courses in a different, but related, discipline. Further, since both of these studies examined performance only during the quarter immediately after the PSI course, the question of long range performance remains unanswered.

Method

The present study investigated the long term effects of PSI as an instructional method in Revelle College at the University of California, San Diego. The subjects took a sequence of courses consisting of three physics courses, followed by a chemistry course, a biology course and a further chemistry course which was not necessary for the breadth requirement but which was required for several majors. The introduction of three PSI physics courses to parallel the lecture physics courses at the beginning of the sequence made the study possible. The sequence began in winter quarter 1972, when the PSI and lecture courses were listed in the schedule of classes identified as the same class taught by different instructors. Neither instructor had taught any course in the college within the previous two years. Thus, students registered for one physics course or the other without prior knowledge of the teaching method to be used or bias about the instructor.

Once enrolled, students were not allowed to transfer into lecture physics from PSI or vice-versa. The students enrolled in the PSI courses then became the experimental group and the students enrolled in the lecture class served as a control group. High school grade point average (HS GPA), SAT Math score (SATM), SAT Verbal score (SATV) and fall, 1971, GPA at Revelle College (F71 GPA) were gathered for students in the two groups to test for randomization.

Data on the performance of the subjects were gathered

during the subsequent required chemistry course, the biology course and the optional chemistry course, all of which followed physics in the science course sequence. These three courses were conventionally taught using lectures and discussion sections. The average grade received by each of the two groups was recorded for each class. In addition, the background data (HS GPA, SATV, SATM, F71 GPA) were used to compare the students from each of the two groups who completed each course being investigated. This step provided a measure of the ensure that selective attrition from one or the other of the groups did not prejudice the comparison.

Data were also compared on the performance of students from the two groups who elected a major in science. All major areas which required the particular natural science sequence in question were examined. They consisted of Applied Mechanics and Engineering Sciences (AMES), Biology, Chemistry and Physics. The grades received for each course taken within the major department during the student's junior year were recorded. The background data (HS GPA, SATV, SATM, F71 GPA) were used to compare the two groups of science majors to check for possible selective attrition.

Results

Table 1 shows the background data for the experimental group (PSI) and the control group (lecture). These groups were approximately equal in size with 139 students in the PSI group and 137 students in the lecture group. There were no

significant differences between the two groups on HS GPA, SATV, or SATM. However, the lecture group had significantly higher F71 GPA than the PSI group, $t(274) = 2.35$, $p < .05$.

Table 1

Background data on the PSI and lecture physics students who completed the first three physics courses in the natural science sequence

	HS GPA	SAT V	SAT M	Fall 71 UC GPA
PSI (N=139)	3.604	575.7	654.7	3.135
Lecture (N=137)	3.592	574.2	653.0	3.295
Difference	.014	1.5	1.7	- .160
t	.231	.120	.185	- 2.350*

*$p < .05$

Table 2 presents data on the 89 students from the PSI group and 70 students from the lecture group who subsequently completed the first chemistry course. There were no significant differences between the lecture and PSI groups on any of the variables in the background data.[1] The PSI group achieved a significantly higher grade in the Chemistry I course than the lecture group ($p < .01$).

[1] The data or grades received in Chemistry I, Chemistry II, Biology, and junior year courses were heavily skewed. For this reason, a distribution free statistical test, the Mann-Whitney U-test (Siegel, 1956) was chosen to test the significance of between-group differences on these variables.

Table 2

Background data and average grade in subsequent Chemistry I class for physics PSI and physics lecture students

	HS GPA	SAT V	SAT M	Fall 71 UC GPA	Chem I Average Grade
PSI (N=89)	3.678	584.2	668.9	3.184	2.658
Lecture (N=70)	3.694	574.9	661.2	3.312	2.309
Difference	- .016	9.3	7.7	- .128	.349**
t	- .341	.623	.609	-1.767	----

** $p < .01$ by the Mann-Whitney U-test

Table 3 presents data on the 70 students from the PSI group and 46 students from the lecture group who subsequently completed the second chemistry course. There are no significant differences between the two groups on any of the variables in the background data. The PSI group achieved a significantly higher grade in the Chemistry II course than the lecture group ($p < .01$).

Table 3

Background data and average grade in subsequent Chemistry II class for physics PSI and physics lecture students

	HS GPA	SAT V	SAT M	Fall 71 UC GPA	Chem II Average Grade
PSI (N=70)	3.656	589.7	668.0	3.179	3.027
Lecture (N=46)	3.693	574.8	653.0	3.311	2.675
Difference	- .037	14.9	15.0	- .132	.352**
t	- .666	.824	1.041	-1.516	----

** $p < .01$ by the Mann-Whitney U-test

Table 4 presents data on the 59 students from the PSI group and 60 students from the lecture group who subsequently completed a biology course. Again, there are no significant differences between the two groups on any of the variables in the background data. The students from the PSI group achieved significantly higher grades than the lecture group students in the biology course ($p < .01$).

Table 4

Background data and average grade in subsequent biology class for physics PSI and physics lecture students

	HS GPA	SAT V	SAT M	Fall 71 UC GPA	Biology Average Grade
PSI (N=79)	3.682	594.4	665.0	3.192	2.797
Lecture (N=60)	3.702	567.5	645.8	3.274	2.467
Difference	- .020	26.9	19.2	- .082	.330**
t	- .405	1.666	1.481	-1.007	----

** $p < .01$ by the Mann-Whitney U-test

Table 5 presents background data on the students who subsequent to the physics PSI and lecture courses majored in Applied Mechanics and Engineering Sciences (AMES), Biology, Chemistry and Physics. For simplicity, this data has been aggragated into two groups, one for the lecture group students and one for the PSI group students. These data indicate that there is no significant difference on any of the variables in the background data between these students from the PSI group and the lecture group.

Table 5

Background data on students who subsequently decided to major in science (AMES, Biology, Chemistry and Physics) from the physics PSI and physics lecture groups

	HS GPA	SAT V	SAT M	Fall 71 UC GPA
PSI (N=54)	3.632	585.6	653.9	3.214
Lecture (N=53)	3.664	573.6	652.8	3.202
Difference	- .032	12.0	1.1	.012
t	- .5028	.6439	.0679	.1211

Table 6 presents data on the average grades achieved by students from the PSI and lecture groups in junior-year courses within their major. The six PSI group students majoring in AMES achieved significantly higher grades in their junior year AMES courses than did the six lecture group students in the AMES major ($p < .01$). The 25 biology majors from the PSI group achieved significantly higher grades in junior level biology courses than did their 30 lecture group counterparts ($p < .01$). The 11 chemistry majors from the PSI group also achieved significantly higher grades in junior-level chemistry courses than their lecture group counterparts ($p < .01$). Finally, the 12 physics majors from the PSI

group achieved significantly higher grades in their junior year physics courses than the 7 physics majors from the lecture group ($p < .01$).

Table 6

Average grade in major field junior year for physics PSI and physics lecture students

	Ames Average Grade	N	Biology Average Grade	N	Chemistry Average Grade	N	Physics Average Grade	N
PSI	3.562	6	3.333	25	3.284	11	3.454	12
Lecture	1.869	6	2.932	30	3.027	10	2.947	7
Difference	1.693*		.401*		.257*		.507*	

* $p < .01$ by the Mann-Whitney U-test

Discussion

The results of this study indicate that the physics PSI students achieve significantly higher grades than the physics lecture students in biology and chemistry courses following the physics courses in the natural science sequence. This occurred in spite of the fact that the lecture students had significantly higher overall grades during their first quarter at the university. This result seems to confirm that the PSI students were not at a disadvantage in later lecture courses.

The fact that PSI students performed better raises some further questions. The simplest possible explanation is selective attrition. If more good students from the lecture group didn't take the subsequent course, then the grades received by the lecture group students in that subsequent course should be lower than would be expected if all had taken it. However, the measures of motivation/ability used in this study (SAT scores, HS GPA, and F71 GPA) indicated that no such selective attrition occurred. The only systematic bias is the higher F71 GPA received by the lecture group. This supports the hypothesis that something about the three quarters of PSI physics had an effect on the students which caused them to perform better than their counterparts in the lecture course.

Three past studies have shown that PSI students receive higher grades in later courses in the same discipline. It is possible to explain these results by assuming that the PSI students in fact learned more of the material than lecture students since PSI is a mastery system. The present result seems to require a more complicated explanation. This study indicates PSI physics students receive better grades in a subsequent biology course. It is hard to explain this result purely in terms of content acquisition/retention because the two fields are quite distinct in their respective contents. It seems more likely that the PSI students received higher grades because they had developed habits which fostered content

acquisition (we used to call them study habits).

This hypothesis receives further support from the data on the major coursework grade comparisons. Although the physics course was given in their freshman year and the first quarter of the sophomore year, PSI students received significantly higher grades in their majors one year later. While it may be argued that the PSI students' superior content mastery helped them out-perform lecture students in the physics and AMES majors, it is more difficult to apply this argument to the biology and chemistry majors where there seems to be less direct relationship of the content to physics. It should be noted, however, that there may be a positive correlation between the grades in science major coursework and the grades received in the lower division prerequisites of the major. Hence, the higher grades received by PSI students in their science majors might be expected on the bias of differentially higher performance in lower division courses alone.

Further study is needed to isolate the factors within the PSI system that are responsible for these differences. Perhaps only a few of the components of PSI are essential. The interaction of student learning style with instructional method (including PSI) needs to be further explored to determine if all students benefit equally from PSI. Future research will hopefully answer these questions.

Conclusion

Although the reasons why PSI has been shown to be a more effective way to teach introductory science courses are unknown, the results are striking. The group of students who took the PSI physics course received higher grades in later science courses than a similar group of students who took analogous lecture courses. These differences are both statistically and educationally (1/3 of a grade) significant. More research questions need to be answered before wholesale renovations of the curriculum can be justified; however, at the moment the implication seems to be that PSI may be a better way to teach introductory science courses.

References

Anderson, O.T. and Artman, R.A. A Self-Paced, Independent Study Introductory Physics Sequence Description and Evaluation. American Journal of Physics, 1972, 40, 1737-1742.

Austin, S.M. and Gilbert, K.E. Student Performance in a Keller-Plan Course in Introductory Electricity and Magnetism. American Journal of Physics, 1973, 41(1), 12-18.

Born, D.G., Gledhill, S.M. and Davis, M.L. Examination Performance in Lecture-Discussion and Personalized Instruction Courses. Journal of Applied Behavior Analysis, 1972, 5(1), 33-43.

Corey, J.R. and McMichael, J.S. Retention in a PSI Introductory Psychology Course. In J. Sherman (Ed.), PSI: 41 Germinal Papers. Menlo Park: Benjamin, 1974.

Keller, F.S. Good-Bye Teacher. Journal of Applied Behavior Analysis, 1968, 1, 78-89.

Kulik, J.A. PSI: A formative Evaluation. Paper presented at the National Converence on Personalized Instruction in Higher Education, Los Angeles, March, 1975.

Lubkin, J.L. Engineering Statics: A Keller-Plan Course with Novel Problems and Novel Features. In R.S. Ruskin and S.F. Bono (Eds.), Personalized Instruction in Higher Education. Washington, D.C.: Center for Personalized Instruction, 1974.

Morris, C. and Kimbrill, G. Performance and Attitudinal Effects of the Keller Method in an Introductory Psychology Course. Psychological Record, 1972, 22, 523-530.

Sherman, J.G. Applications of Reinforcement Principles to a College Course. In J. Sherman (Ed.), PSI: 41 Germinal Papers. Menlo Park: Benjamin, 1974.

Siegel, S. Nonparametric Statistics. New York: McGraw-Hill, 1956.

Weissburg, H.L. PSI Innovation in the Classroom, Tennessee Engineer, 1973, 28-31.